Broad Scale Modeling

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Contents

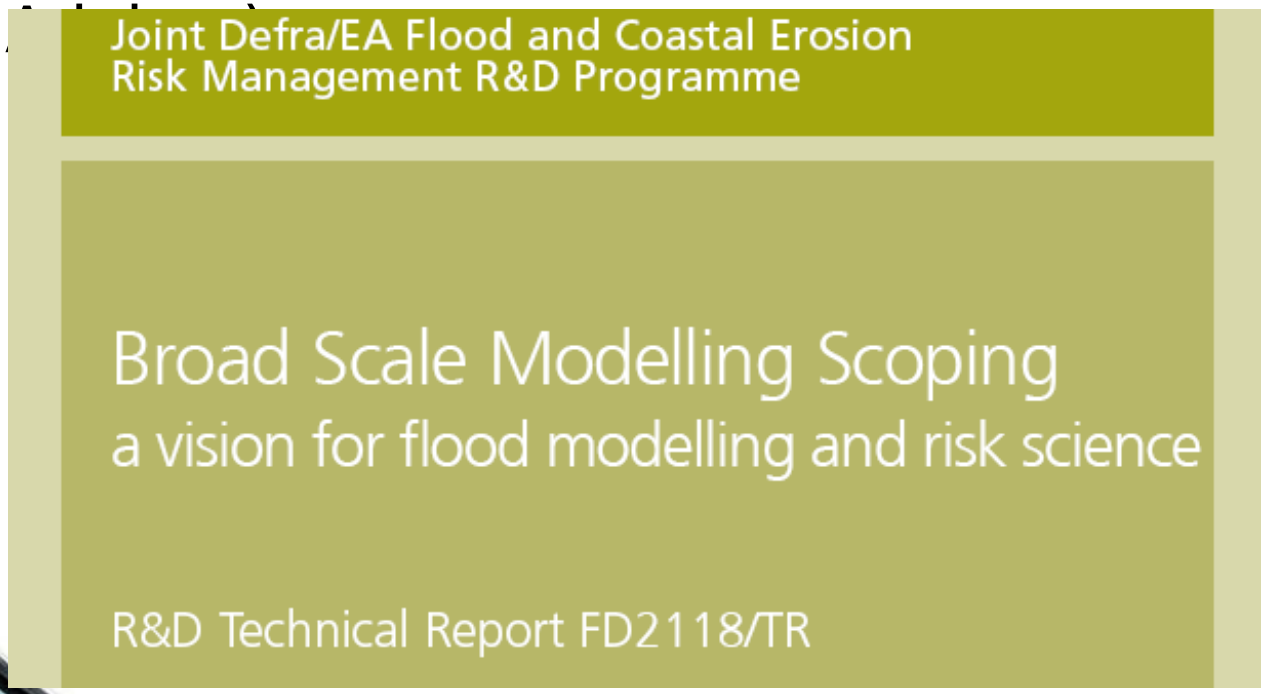
- Introducing ‘broad scale modeling’
- Types of models
- Examples
- Conclusions

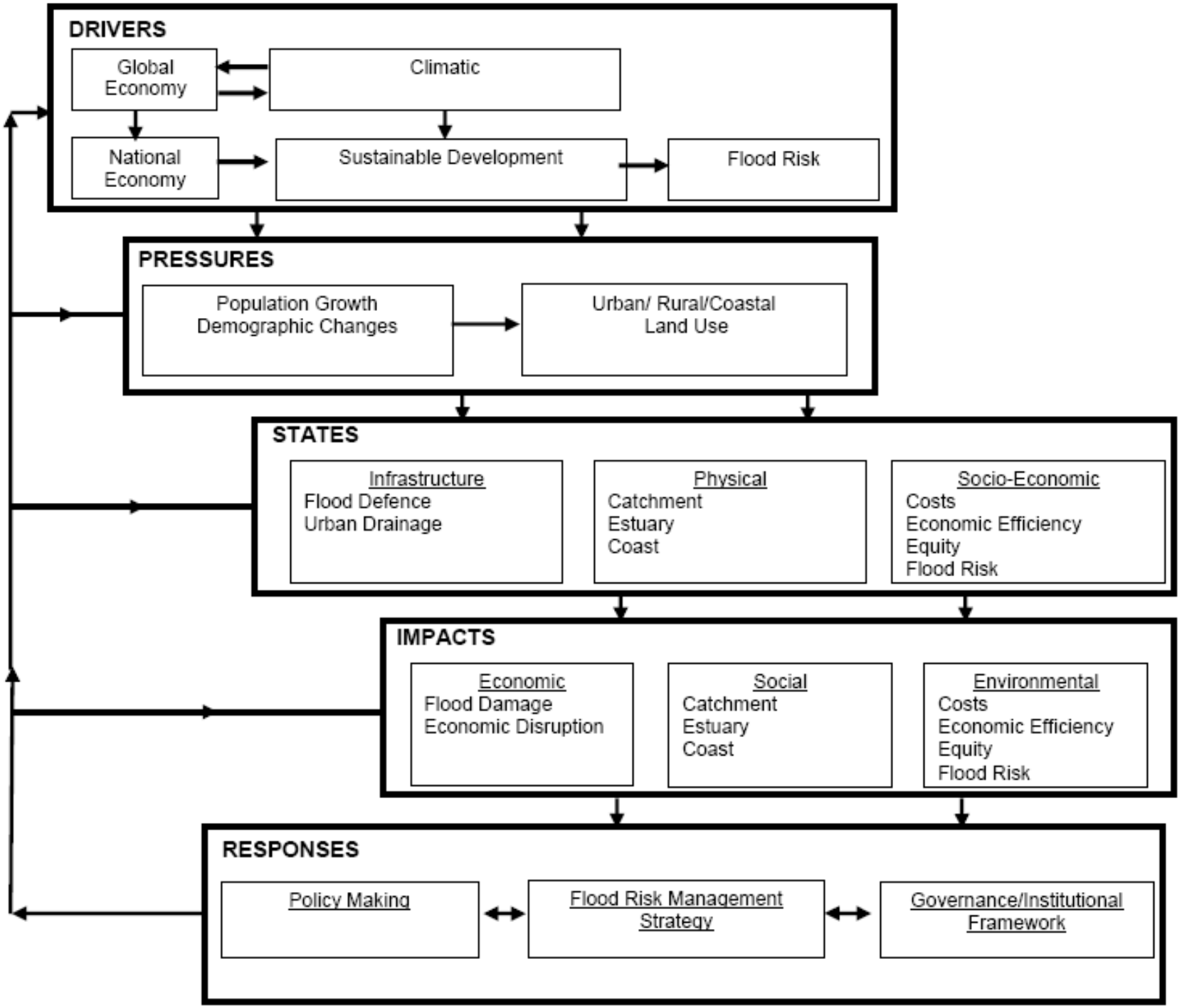
Broad scale modeling

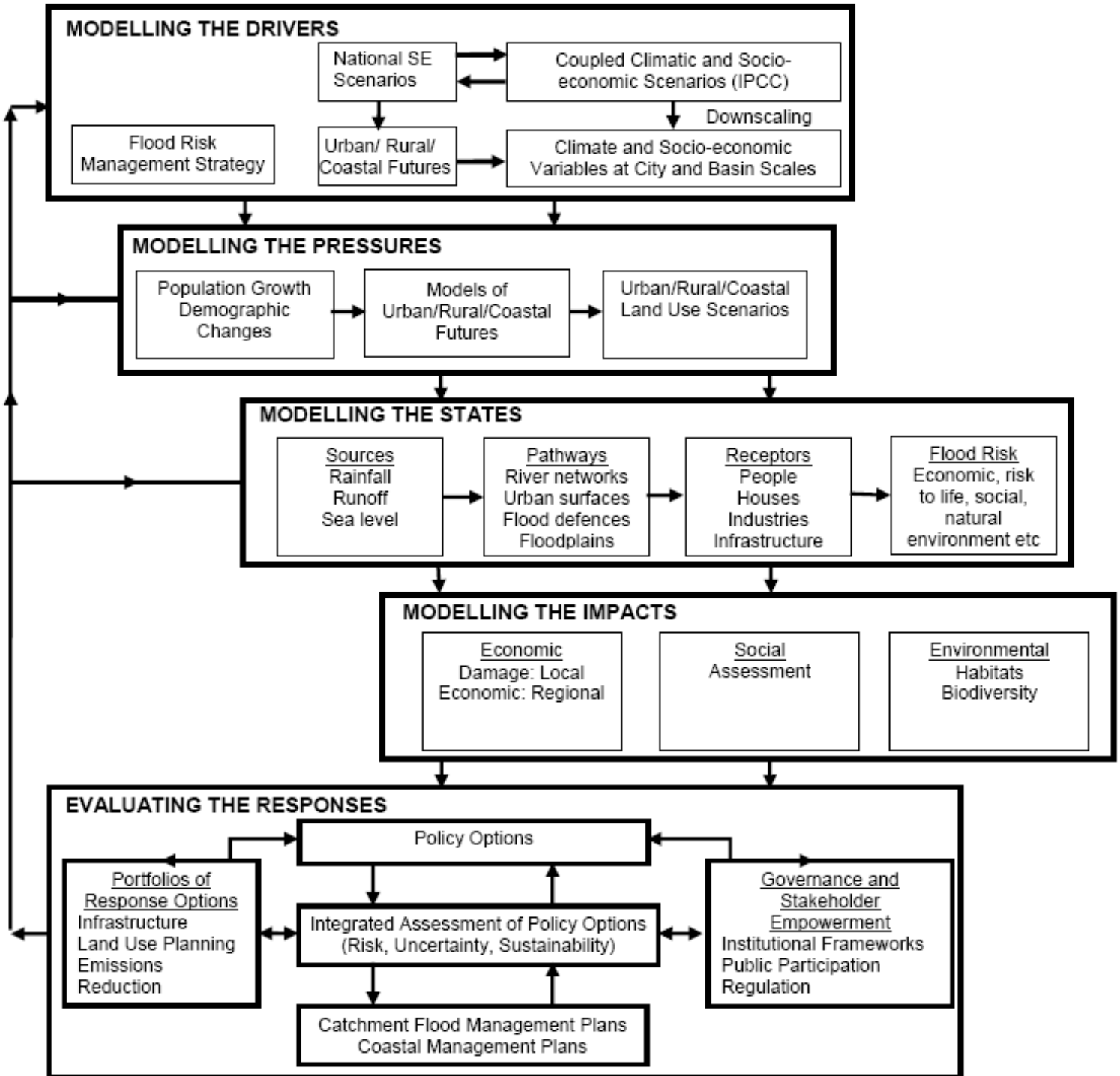
- Predicting trends (eg over 30 to 100 years)
- Sufficient accuracy to inform the making of major policy decisions
- Cover the whole study area thus allowing an integrated view
- Adequately represent the most important physical processes:
  - Existing system (key elements only)
  - Influence of key drivers
  - Influence of key responses
- Usually low resolution (space and time)
- Methods must be sufficiently quick to set up and run
- Simplest approach to support the project aims

Broad scale modeling

- Environment Agency R&D – ‘Modelling and Risk’ theme (Suresh is Theme Manager and Edward is


Joint Defra/EA Flood and Coastal Erosion
Risk Management R&D Programme
Broad Scale Modelling Scoping
a vision for flood modelling and risk science
R&D Technical Report FD2118/TR


DRIVERS
Global Economy
Climatic
National Economy
Sustainable Development
Flood Risk
PRESSURES
Population Growth
Demographic Changes
Urban/ Rural/Coastal
Land Use
STATES
Infrastructure
Flood Defence
Urban Drainage
Physical
Catchment
Estuary
Coast
Socio-Economic
Costs
Economic Efficiency
Equity
Flood Risk
IMPACTS
Economic
Flood Damage
Economic Disruption
Social
Catchment
Estuary
Coast
Environmental
Costs
Economic Efficiency
Equity
Flood Risk
RESPONSES
Policy Making
Flood Risk Management Strategy
Governance/Institutional Framework


MODELLING THE DRIVERS
National SE Scenarios
Coupled Climatic and Socio-economic Scenarios (IPCC)
Downscaling
Flood Risk Management Strategy
Urban/ Rural/ Coastal Futures
Climate and Socio-economic Variables at City and Basin Scales
MODELLING THE PRESSURES
Population Growth Demographic Changes
Models of Urban/Rural/Coastal Futures
Urban/Rural/Coastal Land Use Scenarios
MODELLING THE STATES
Sources
Rainfall
Runoff
Sea level
Pathways
River networks
Urban surfaces
Flood defences
Floodplains
Receptors
People
Houses
Industries
Infrastructure
Flood Risk
Economic, risk to life, social, natural environment etc
MODELLING THE IMPACTS
Economic
Damage: Local
Economic: Regional
Social
Assessment
Environmental
Habitats
Biodiversity
EVALUATING THE RESPONSES
Policy Options
Portfolios of Response Options
Infrastructure
Land Use Planning
Emissions Reduction
Integrated Assessment of Policy Options (Risk, Uncertainty, Sustainability)
Governance and Stakeholder Empowerment
Institutional Frameworks
Public Participation
Regulation
Catchment Flood Management Plans
Coastal Management Plans

Types: Example of prediction of flooding

- Hydrological and hydraulic modeling to predict (primarily):
  - flows in rivers and other channels
  - water levels in rivers, channels, lakes
  - overtopping/breaching inflows (fluvial and coastal)
  - **flood depths and extents on the floodplain**

    → **impacts people, economy, environment**

Example types of flooding model

- Conceptual
- Static (predefined, non-interactive) Hydrological routing
- 1D Steady-state
- 1D Unsteady hydrodynamic
- Quasi-2D flood cell ('reservoir' units)
- 2D 'raster routing'
- 2D hydrodynamic
- Linked 1D-2D hydrodynamic
- 3D Hydrodynamic

Consider:

Scope of work

Size of study

Flow mechanisms

Data availability

Data accuracy

Certainty/uncertainty

Costs

Enhanced value

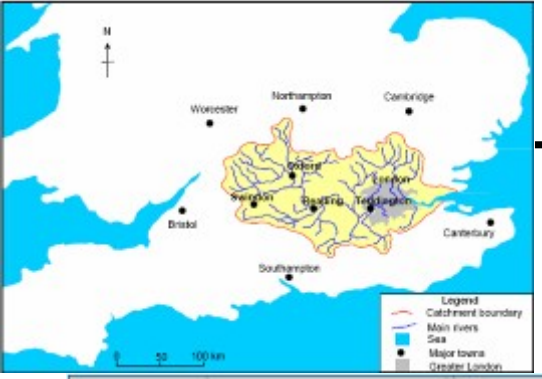
Software availability

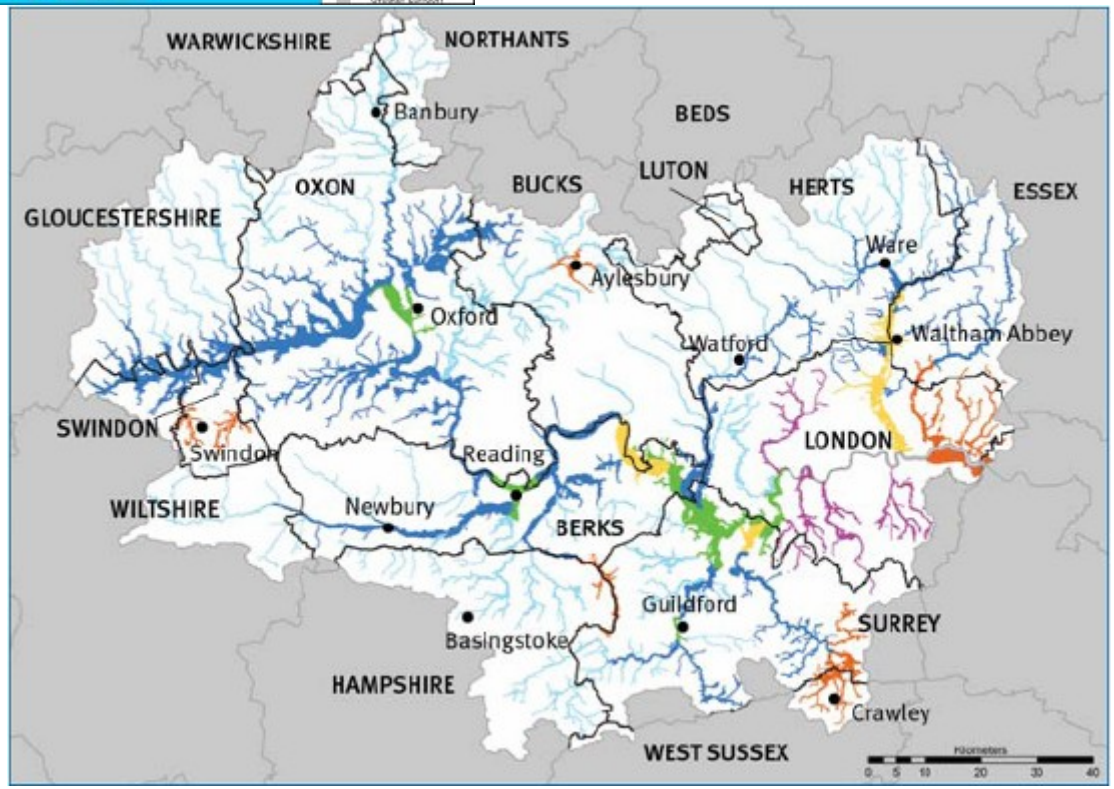
Skill base

Broad scale modeling examples

- Thames
- Mekong Basin
- China Flood Foresight – Taihu Basin
- UK Flood Foresight

Thames Catchment CFMP

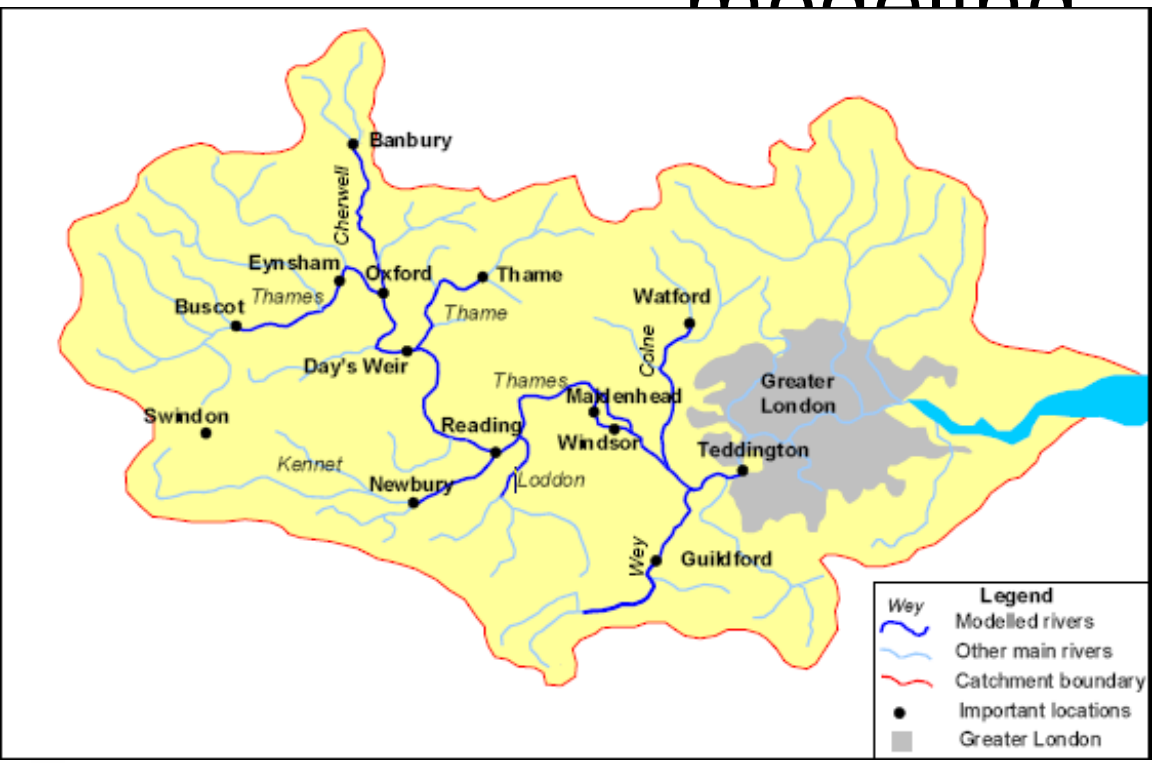




- Undeveloped natural flood plain
- Developed flood plain with no built flood defences
- Developed flood plain with built flood defences
- Developed flood plain with typically concrete river channels
- Major urban expansion in or close to flood plains
- Narrow flood plains and mixed land use

- 10,000 km^2
- ¼ of population of England and Wales
- Many river control structures (navigable river)

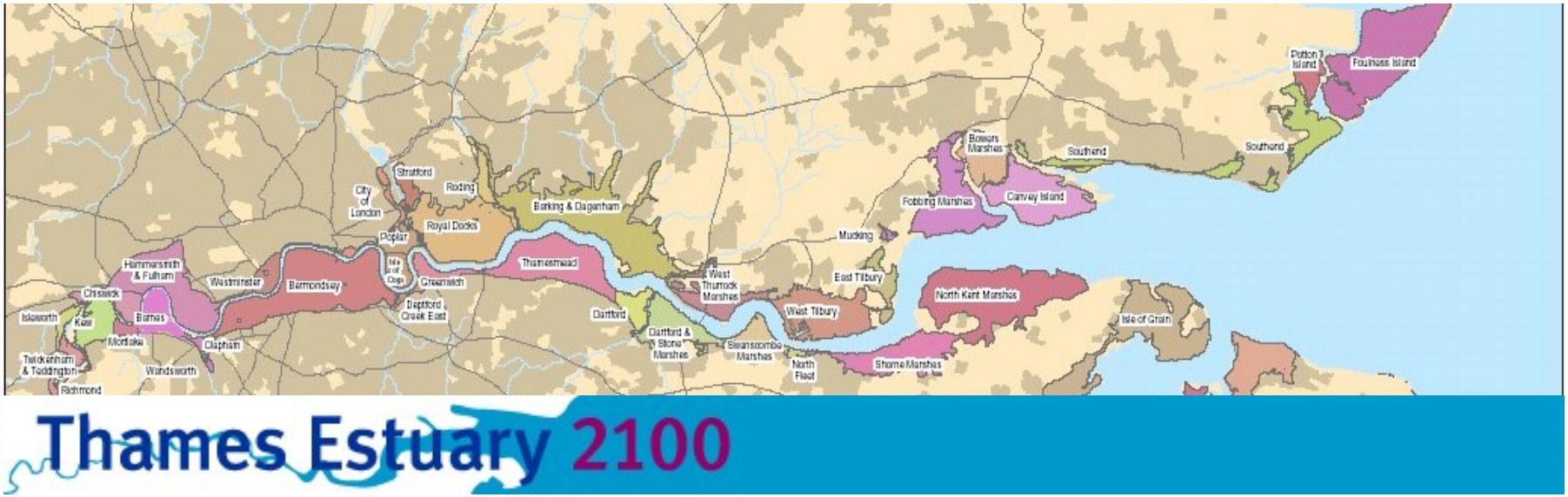
Thames Catchment CFMP modeling



- 44 sub catchments
- 175 nodes using ISIS routing (VPMC) to predict flows
- Stage-discharge relationships from more detailed ISIS models used to generate water levels

Thames Catchment – messages informed by broad scale modeling

- Flood defences cannot be built to protect everything – need to focus resources based on risk (not likelihood)
- Climate change will be the major cause of increased flood risk in the future – winter floods more often and increased thunderstorms in urban areas
- Flood plain is the most important asset in managing flood risk – recognised downstream benefits of natural storage



Thames Estuary 2100

Develop a Flood Risk Management Plan for London and the Thames Estuary that is:

- risk based,
- takes into account existing and future assets,
- is sustainable,
- is inclusive of all stakeholders, and
- addresses the issues in the context of a changing climate and varying socio economic scenarios that may develop over the next 100 years

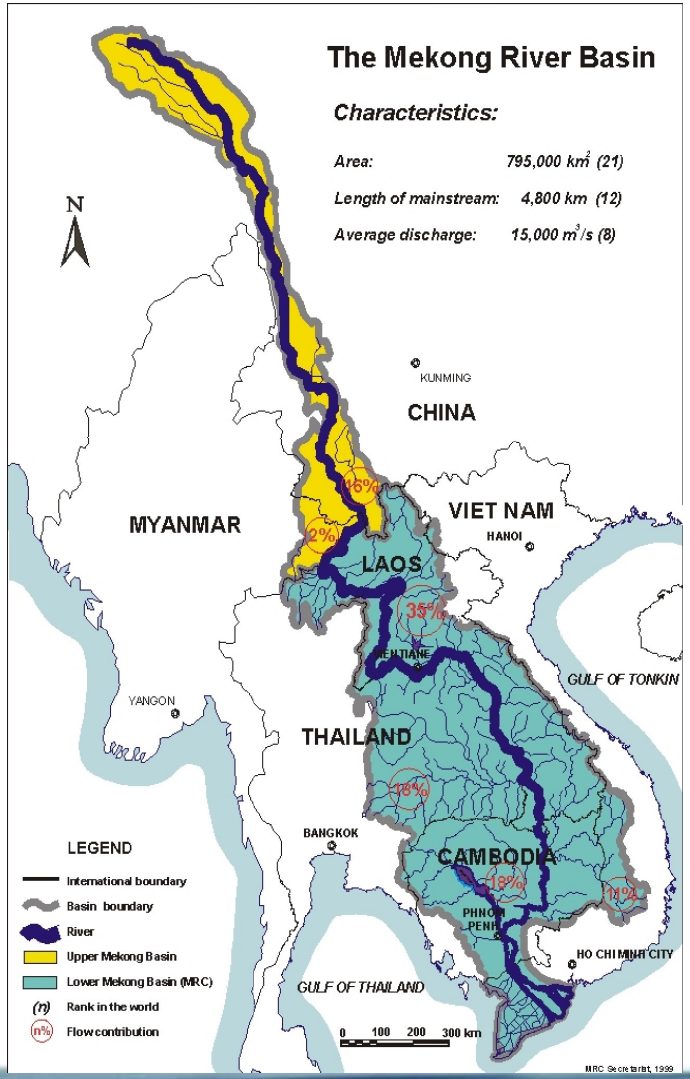
Thames Estuary 2100 - Modeling

- Many types of flood modeling used:
  - Conceptual, 1D, 2D…
- Currently using linked 1D/2D (ISIS-TUFLOW) to appraise options
- 7 ‘options’ and 2 baselines
- 2 climate change scenarios
- Epochs: 2007, 2020, 2030, 2040, 2050, 2080, 2085, 2100, 2115, 2170
- Overtopping, breaching, Barrier failure – fluvial, tidal

→ environmental, economic and social impact including direct property damage and ‘risk to life’

Mekong broad scale model

- Project by Halcrow for Mekong River Commission (MRC) – organisation including Vietnam, Cambodia, Thailand and Laos
- Lower Mekong broad scale model (600,000 km^2)
- > 60 million people



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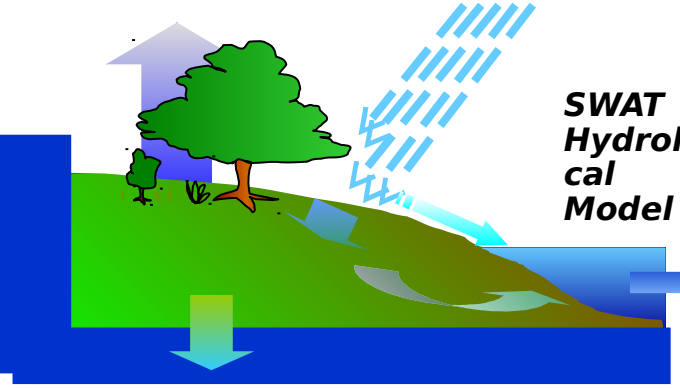
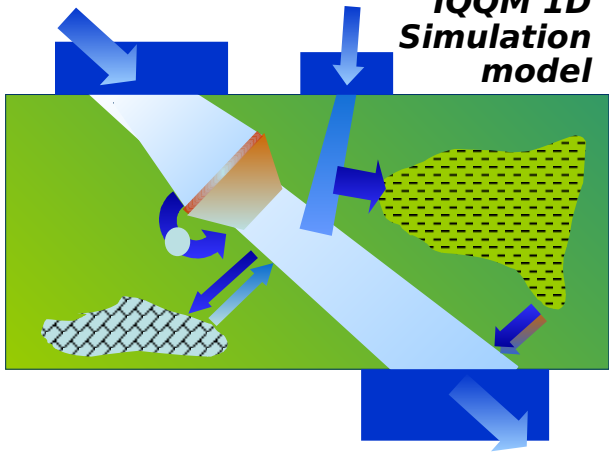
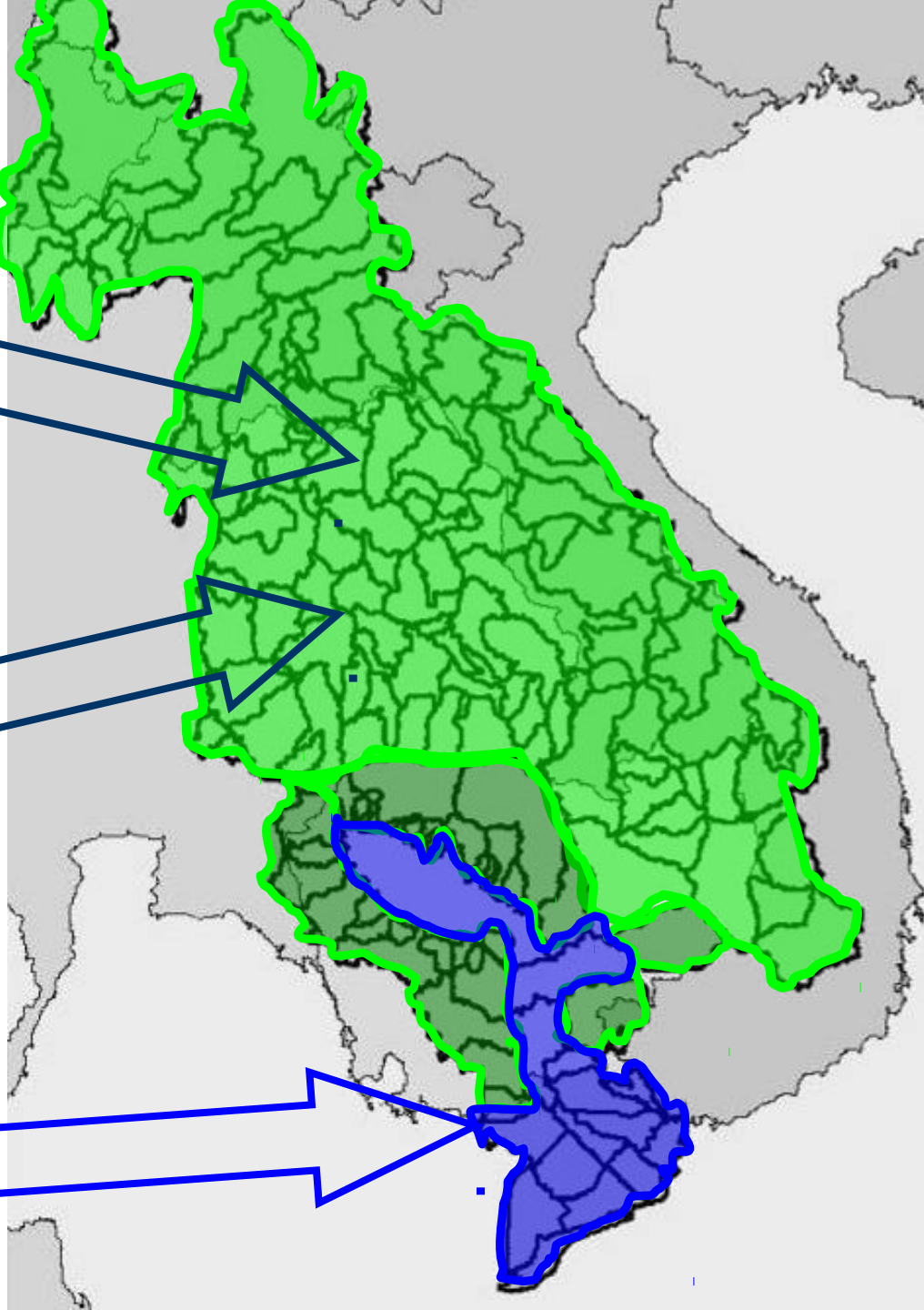


SWAT Hydrological Model

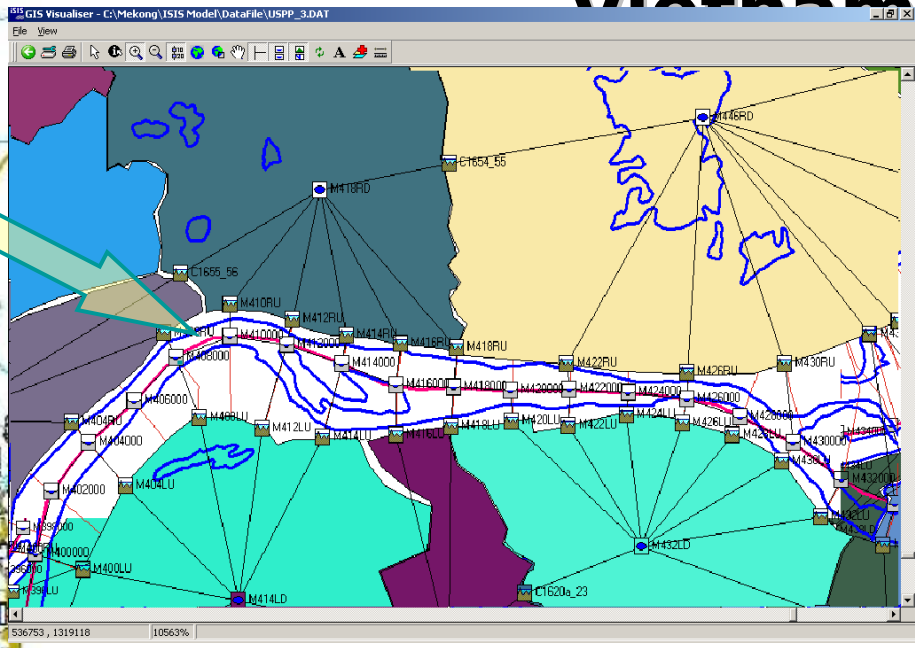


IQQM 1D Simulation model

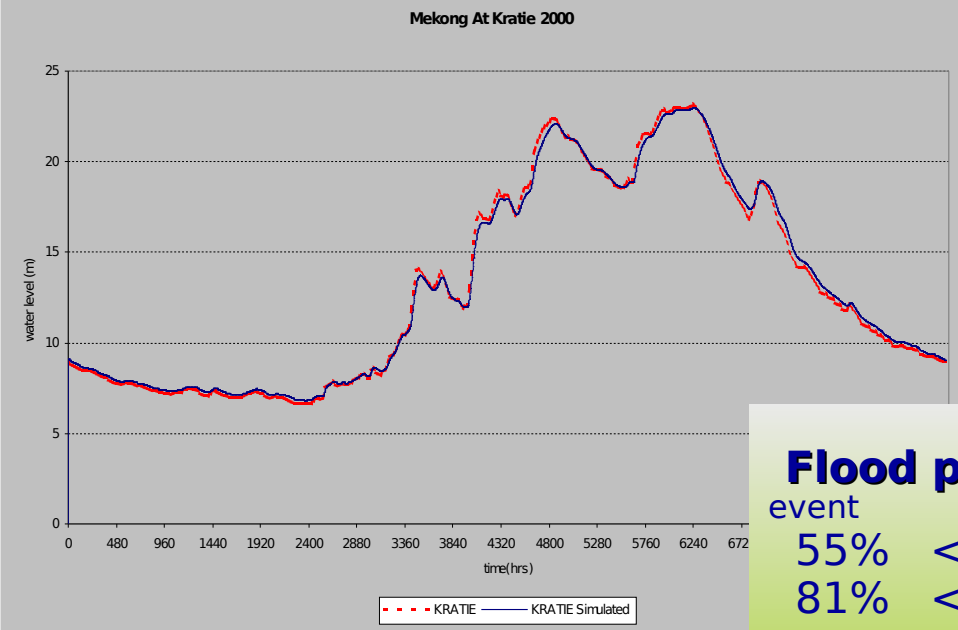
ISIS Hydrodynamic model

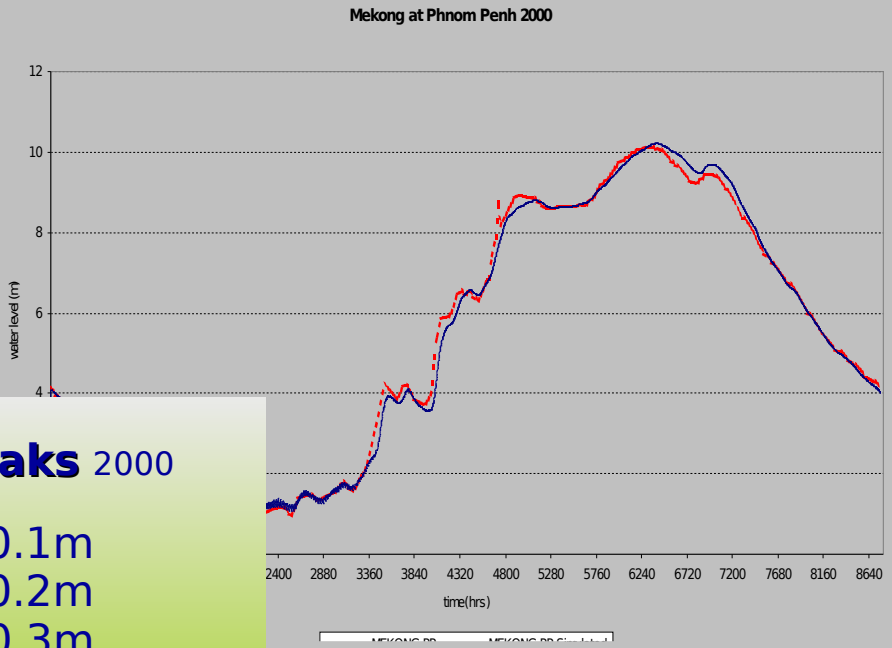


ISIS Model of Cambodia & Vietnam



- 4km spacing (typical)
- 5000 nodes





Flood peaks 2000 event

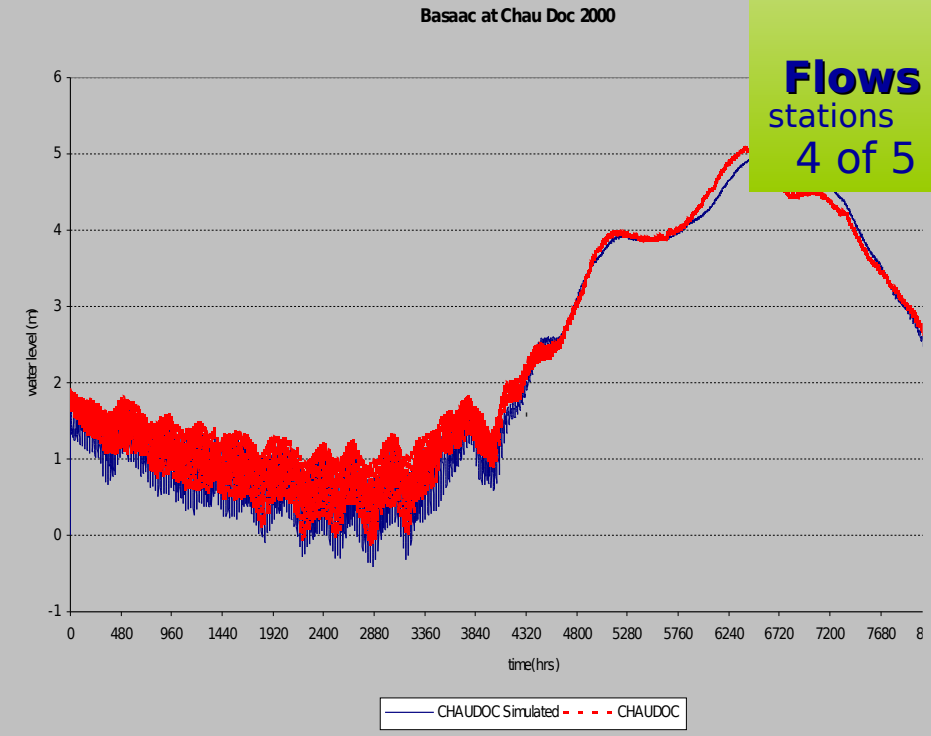
55% < 0.1m

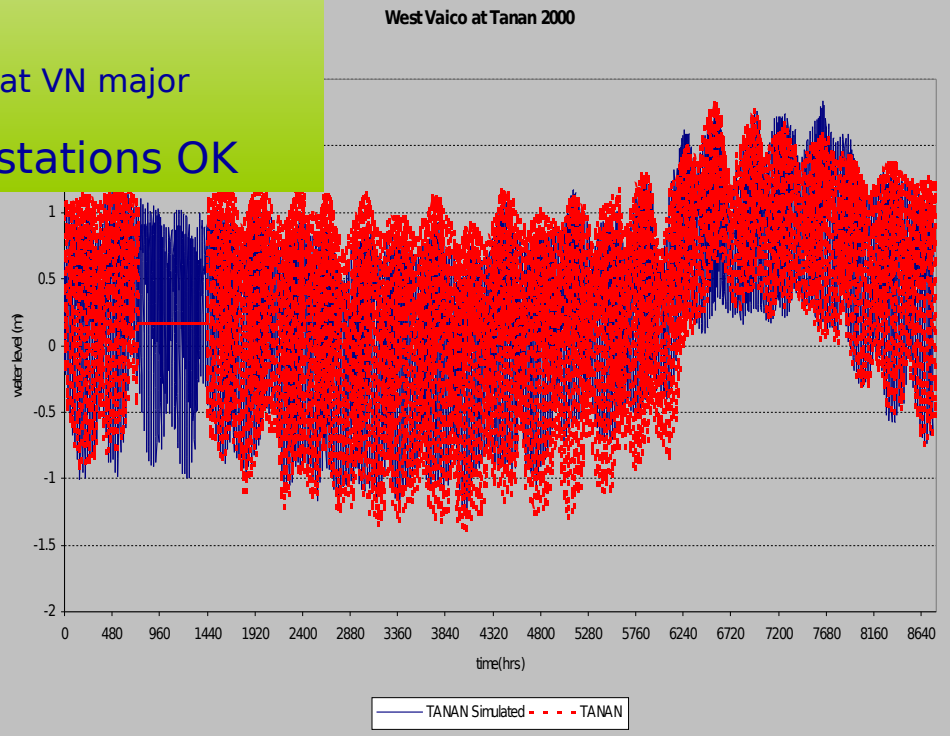
81% < 0.2m

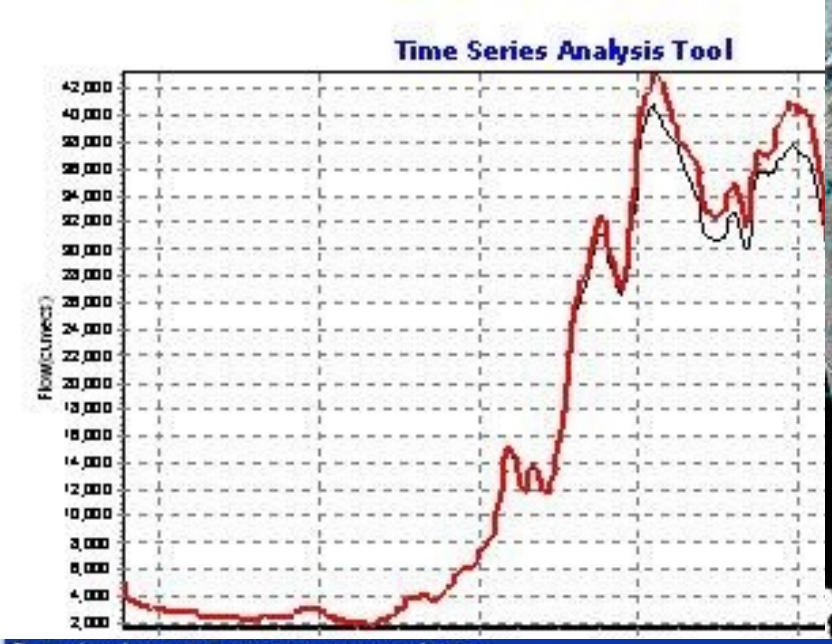
100% < 0.3m

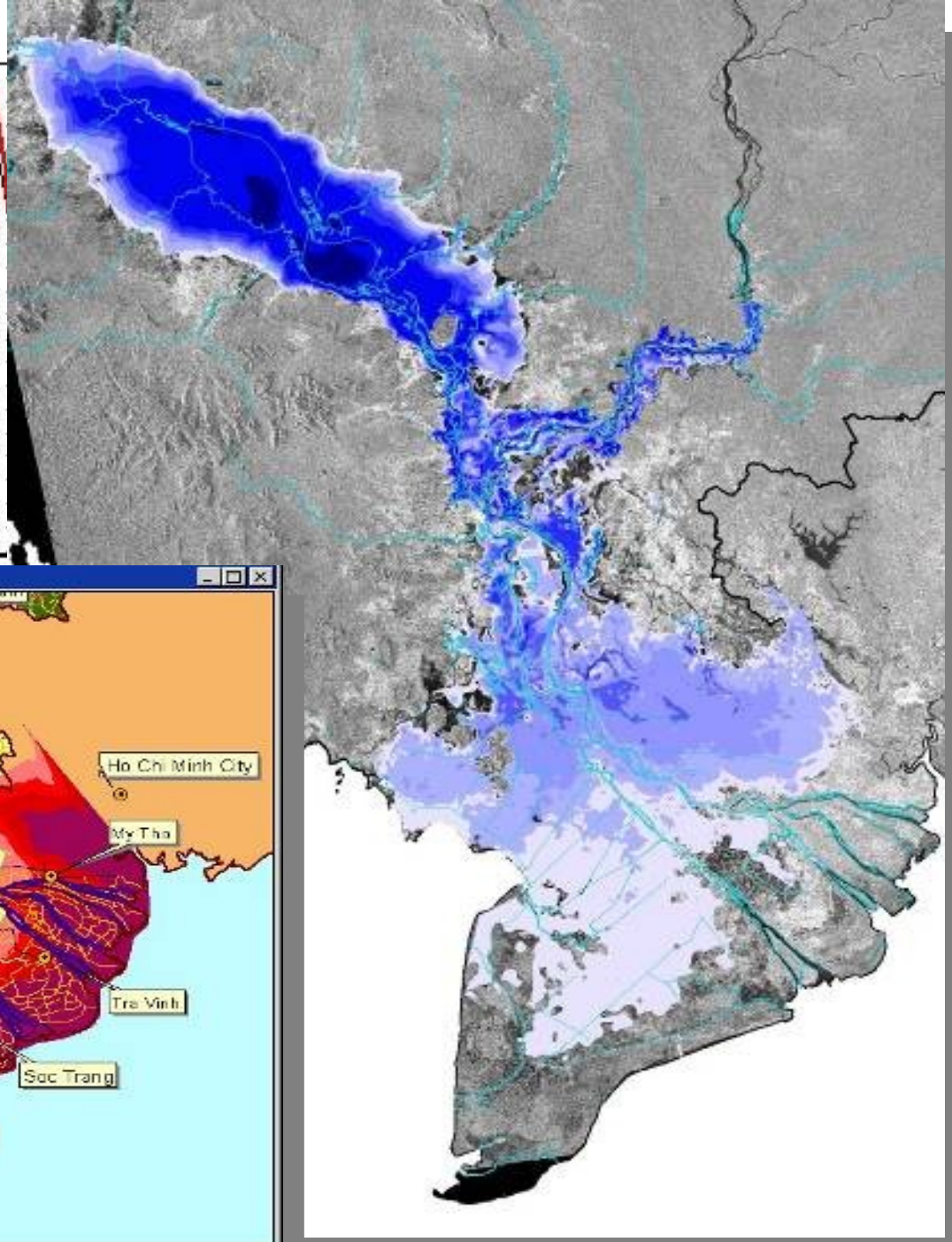
Flows at VN major stations

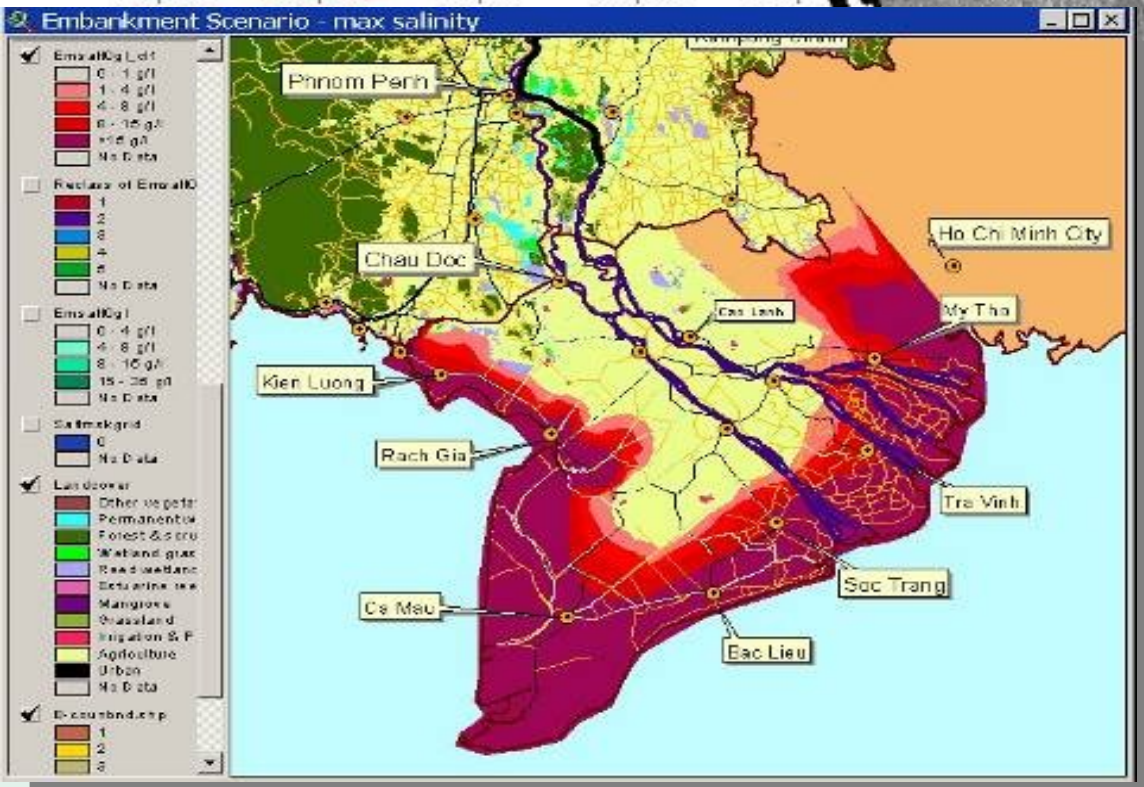
4 of 5 stations OK



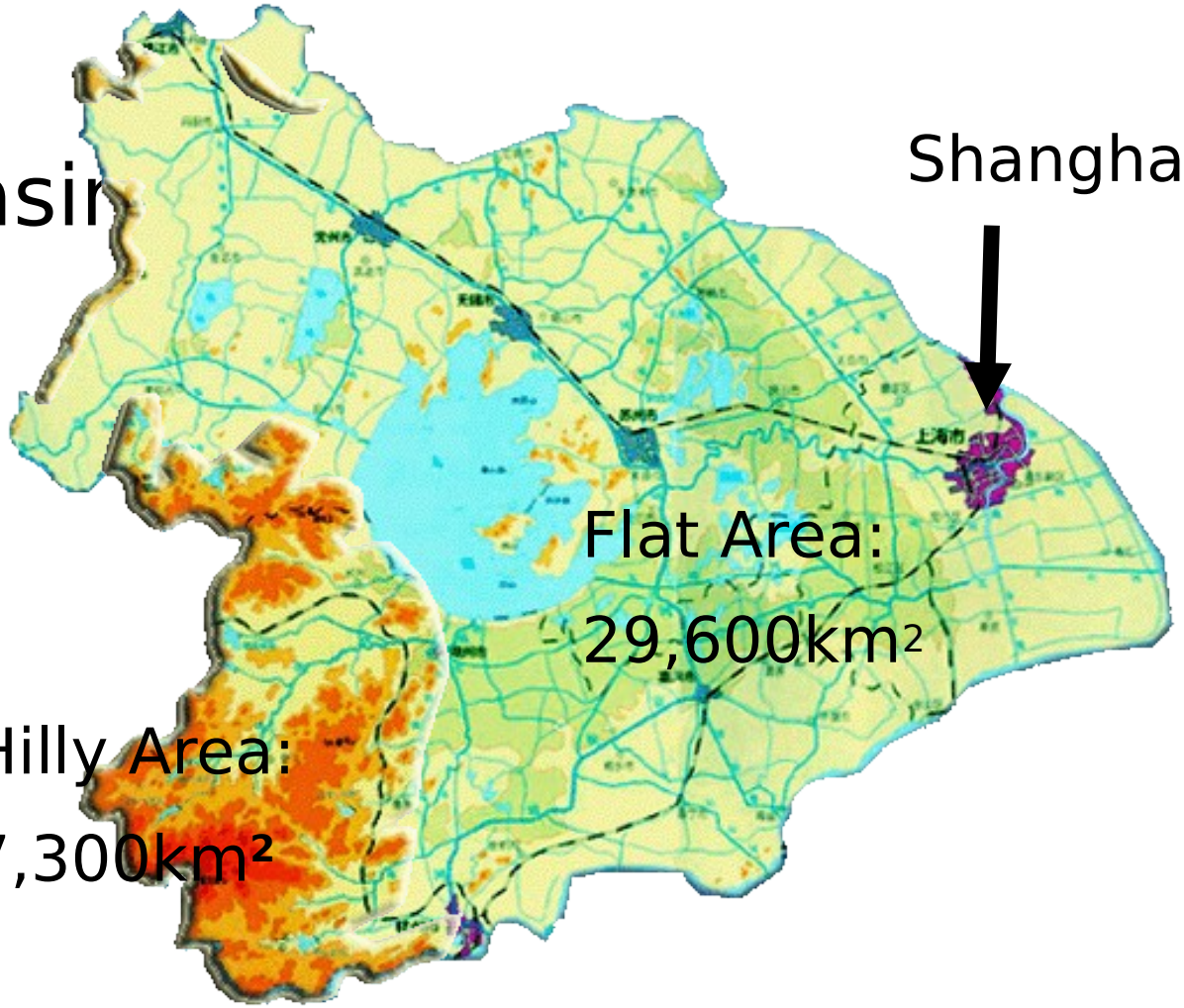


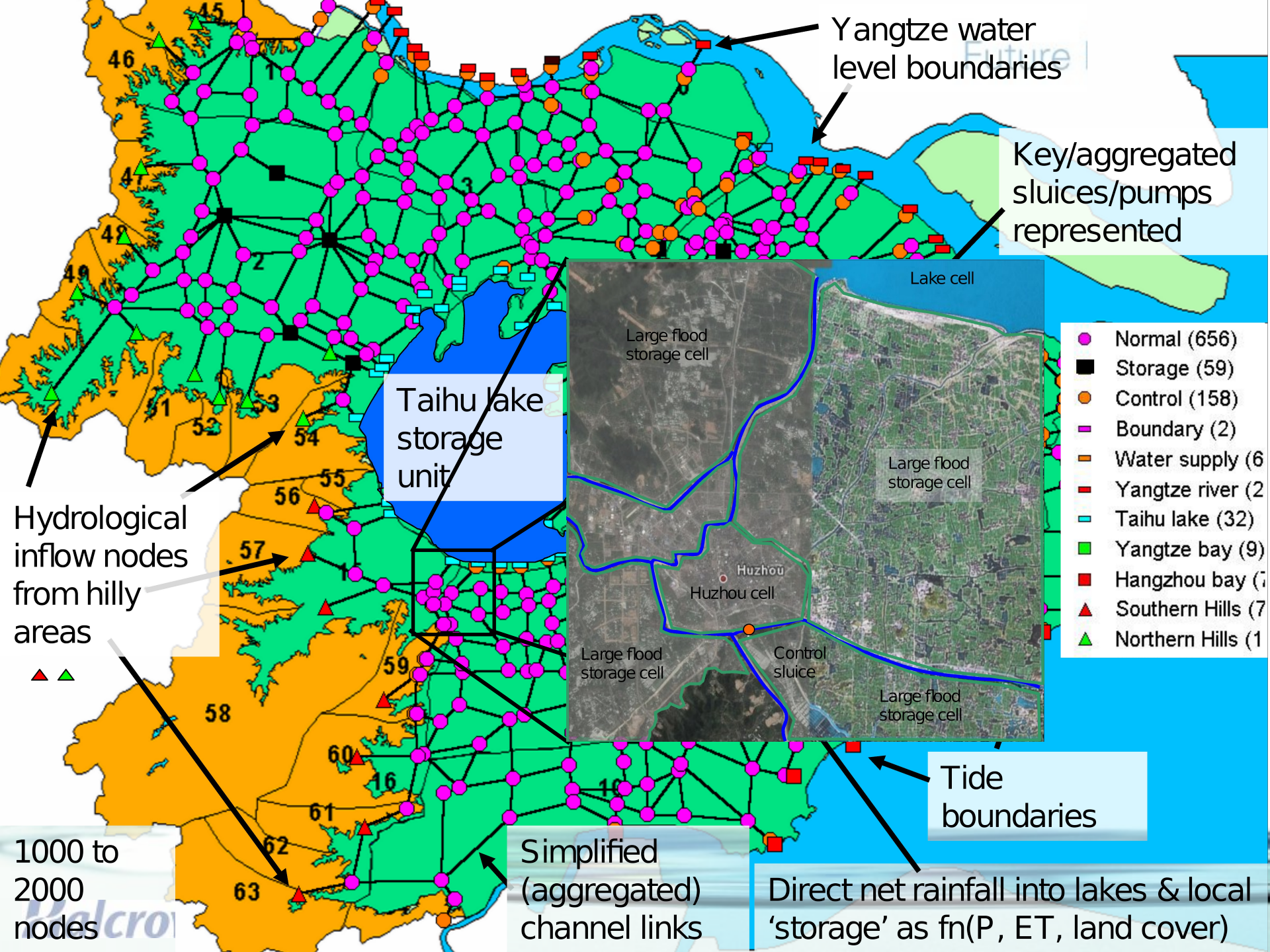

Time Series Analysis Tool
Flow (cumec)




Embankment Scenario - max salinity
Phnom Penh
Chau Doc
Ho Chi Minh City
My Tho
Kien Luong
Rach Gia
Tra Vinh
Soc Trang
Ca Mau
Bac Lieu

Flood Foresight - China




Yangtze water level boundaries
Key/aggregated sluices/pumps represented
Taihu lake storage unit
Hydrological inflow nodes from hilly areas
1000 to 2000 nodes
Simplified (aggregated) channel links
Direct net rainfall into lakes & local 'storage' as fn(P, ET, land cover)
Tide boundaries
Lake cell
Large flood storage cell
Large flood storage cell
Huzhou
Huzhou cell
Large flood storage cell
Control sluice
Large flood storage cell
Normal (656)
Storage (59)
Control (158)
Boundary (2)
Water supply (6
Yangtze river (2
Taihu lake (32)
Yangtze bay (9)
Hangzhou bay (7
Southern Hills (7
Northern Hills (1

Inclusion of drivers in model

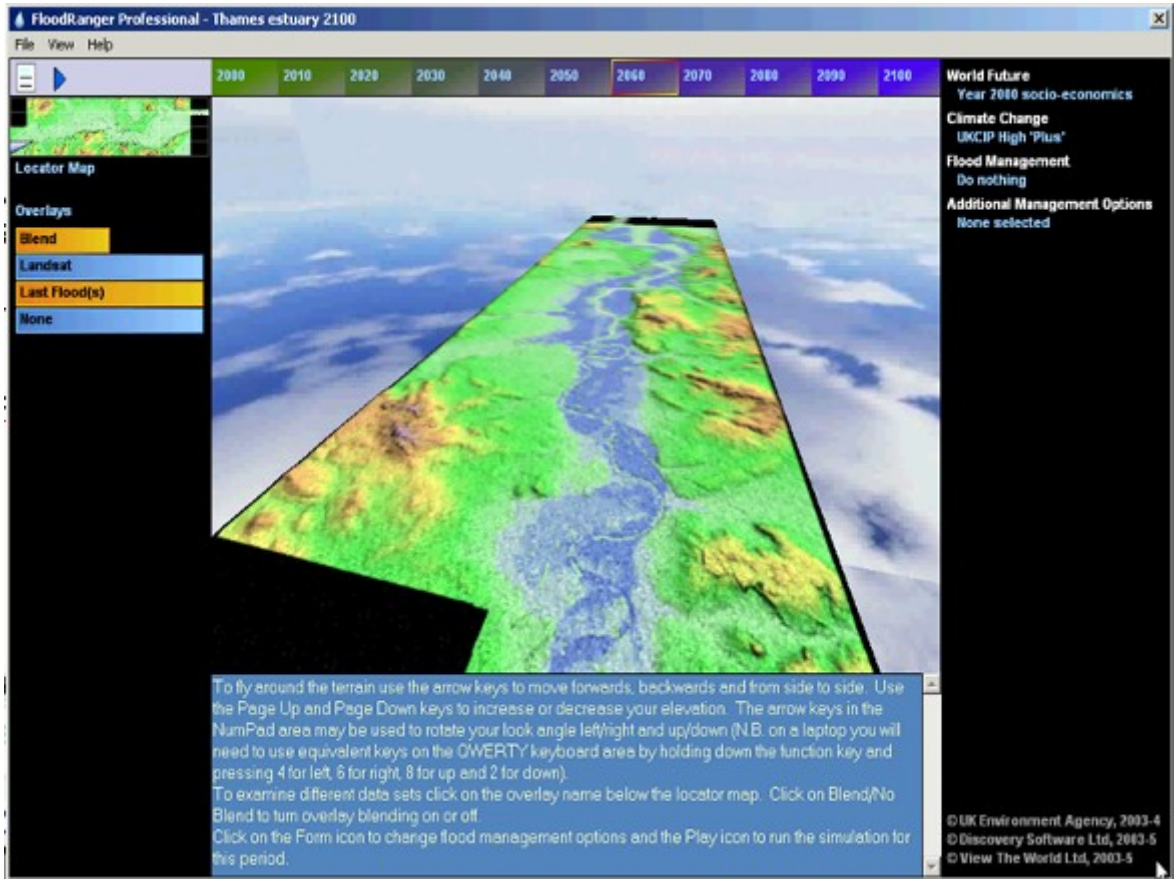
Driver	Brief description	Representation in risk model
Rainfall	Changing rainfall intensity, duration and seasonality due to climate change	Rainfall input time series
Upland catchment change	The effect of changed rates of runoff from the western hills, due to construction of reservoirs, changes in reservoir control rules and land use change	Parameterisation of rainfall-runoff model
Mean sea level rise	Increasing mean sea level due to climate change	Shift in tidal boundary to drainage system
Urbanisation (pathway impacts)	Construction of ring-dyke/ pumping systems and blocking or filling of drainage channels accompanying urbanisation	Changing storage and conveyance within developed areas
Subsidence	Local and regional land lowering	Changes in DEM
Land use (receptors)	Increasing urban land cover leading to increasing exposure to flood risk	Change in urban area in damage assessment
Value of building contents and economic activity	Increasing value of buildings and industry in the floodplain	Change in depth damage functions

Direct inclusion in hydraulic model shown yellow

UK Flood Foresight

Future Flooding

- National scale
- RASP tool (covered later by Jim/Paul)
  - High level, doesn't simulate the flow of water through river network
- FloodRanger
  - Educational game
  - Thames version
  - Modeling to assist stakeholder engagement


FloodRanger Professional - Thames estuary 2100
File View Help
2000 2010 2020 2030 2040 2050 2060 2070 2080 2090 2100
Locator Map
Overlays
Blend
Landsat
Last Flood(s)
None
World Future
Year 2080 socio-economics
Climate Change
UKCIP High 'Plus'
Flood Management
Do nothing
Additional Management Options
None selected
To fly around the terrain use the arrow keys to move forwards, backwards and from side to side. Use the Page Up and Page Down keys to increase or decrease your elevation. The arrow keys in the NumPad area may be used to rotate your look angle left/right and up/down (N.B. on a laptop you will need to use equivalent keys on the QWERTY keyboard area by holding down the function key and pressing 4 for left, 6 for right, 8 for up and 2 for down).
To examine different data sets click on the overlay name below the locator map. Click on Blend/No Blend to turn overlay blending on or off.
Click on the Form icon to change flood management options and the Play icon to run the simulation for this period.
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Conclusions

- Broad scale modeling is commonly used in UK and internationally to better understand water related issues in an integrated way

- Must be able to adequately represent:
  - Existing system (key elements only) → build faith in model
  - Influence of drivers and responses → predictions of future

- Selection of precise tools involves many factors, including people skills and existing models and data
- Recognition that the results of the analysis are broad scale, in the sense that they will be of sufficient accuracy to inform/influence the making of policy decisions (evidence base)

"A lot of thought and a little modeling is better than a lot of modeling and a little thought"